CLIMATE RISK PROFILE SERIES

ADAPTING GREEN INNOVATION CENTRES TO CLIMATE CHANGE: ANALYSIS OF VALUE CHAIN ADAPTATION POTENTIAL

Sesame and rice in Sud-Ouest, Hauts-Bassins, Boucle du Mouhoun, and Cascades Regions, **Burkina Faso**

Alliance
Bioversity International
CIAT International Center for Tropical Agriculture
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
CGIAR
RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security
CCAFS

ABOUT THIS REPORT

Climate change is affecting agriculture more than any other sector. Increased frequency and severity of drought, flood, heat, and unseasonable rainfall heavily impact rainfed agriculture, ultimately resulting in production losses. In that context, The Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) through its climate action lever, are developing climate risk profiles for agricultural value chains in developing countries at the national and subnational level. These profiles build on past work conducted by CIAT and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)in collaboration with the World Bank and other partners, including FAO, USAID, DFID[1].

The present report aims to provide a climate and vulnerability analysis of the Green Innovation Centres (GIC) target commodity value chains. Herein we identify climate change- related vulnerabilities, hazards, and opportunities for adaptation to the same. Ultimately, our goal is to foster awareness of risks and adaptation priorities in the selected value chains and inform climate investments and planning through the recommendations on priority innovations to manage climate risks.

The report begins with an extensive literature reviews of the selected value chains and their key challenges and adaptation strategies. Climate hazards and crop suitability modelling offer insights into potential future scenarios under climate change. These results inform potential adaptation approaches, which are prioritized by in-country experts and stakeholders through an online survey. The top-rated adaptation priorities undergo a cost-benefit analysis. Finally, the results are peer-reviewed by the GIC country office and the Alliance scientific staff.

The **Green Innovation Centres** for the Agriculture and Food Sector (GIC) founded by German Federal Ministry for Economic Cooperation and Development (BMZ) and led by the German Agency for International Cooperation (GIZ) in collaboration with local ministries and programmes, aims to promote agricultural innovation under the *ONEWORLD No Hunger* initiative. Through the GIC, GIZ aims to generate employment raise farmers' income, and improve farmers' education and skills by funding training in good agricultural practices, water management, post-harvest processing, and entrepreneurship.

Planning, data collection and stakeholder engagement
- Literature review (key documents and datasets)

Climate risk assessment
- Hazard analysis
- Crop suitability modelling

Identification of adaptation strategies
- Detailed review
- Gap analysis and identification of climate adaptation
- Online survey
- CBA analysis

Production of the country climate profile and validation
- Peer-review

1 https://ccafs.cgiar.org/publications/csa-country-profiles

HIGHLIGHTS

» Agriculture plays a vital role to the Burkinabe economy, employing more than 80% of the labor force, and contributing to about 28% of the Gross National Domestic Product (GDP). It is also a main source of income, raw materials, and foreign exchange **(Chapter 2, pg. 11).**

» Agricultural sector challenges are several: financial constraints, insufficient availability of improved technologies, and lack of knowledge about them **(Chapter 2, pg. 19).**

» Burkina Faso has made efforts to prioritize climate change initiatives in national adaptation plans, but it still lacks a comprehensive national climate change policy or strategy **(Chapter 3, pg. 20).**

» Climate variability, in particular increase in temperature and moisture stress combined with a decrease in average precipitation impacts agricultural production in Burkina Faso **(Chapter 5, pg. 26).**

» The rice and sesame value chains are most vulnerable to floods and drought. These hazards have implications for crop suitability in the current major production areas **(Chapter 5, pg. 32-34).**

» Strategies such as the use of improved seed varieties, irrigation facilities, run-off water collection, fertilizer, and rice intensification show great promise for boosting farmers' resilience **(Chapter 5, pg. 35-36).**

» Our cost benefit analysis (CBA) analysis ascertains that the adoption of improved rice variety (*Orylux*) is a profitable and low risk investment among farmers. It is however capital intensive **(Chapter 6, pg. 41-42).**

» Conclusively the adaptation potential for the selected value chains is promising with the right support. Opportunities exist to expand the supportive policy environment and to increase collaboration between the public and private sector in Burkina Faso with the goal of expanding farmers' adaptive capacity against climate change effects **(Chapter 7, pg. 44).**

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ACRONYMS AND ABBREVIATIONS

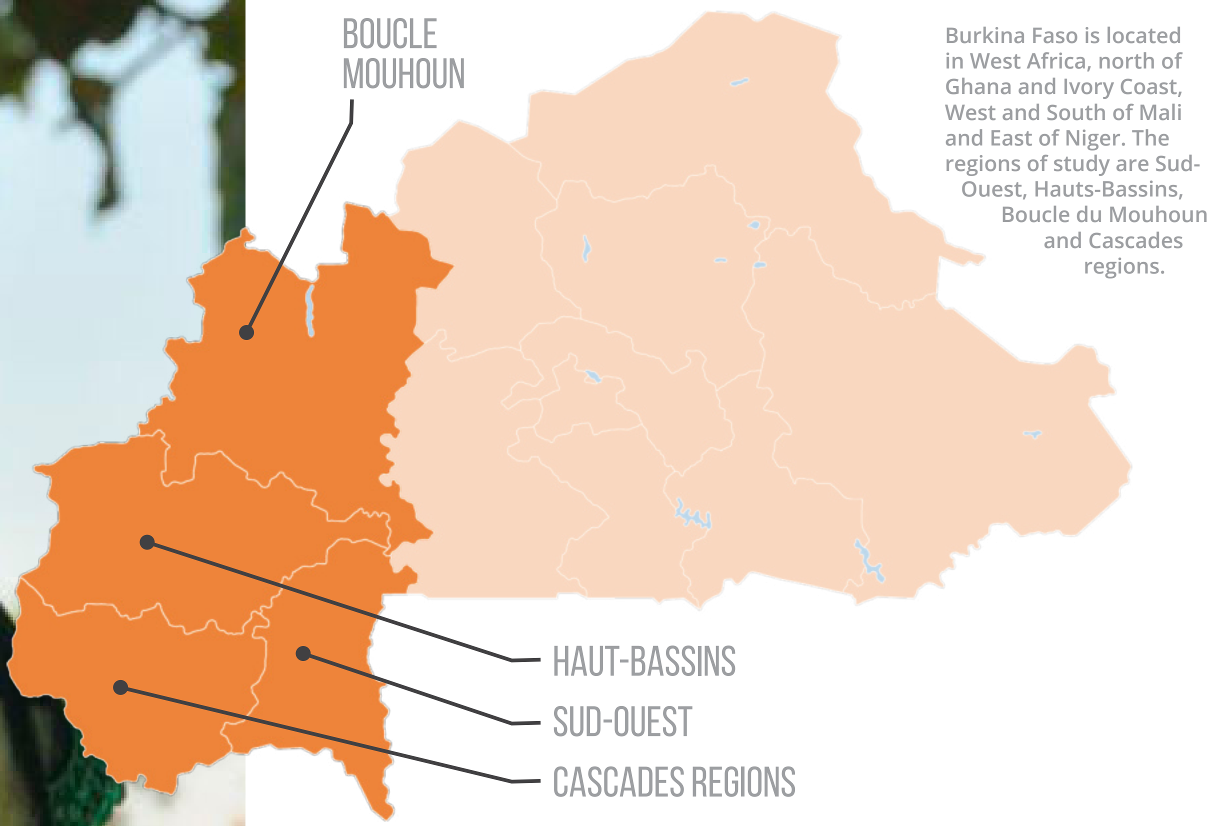
AVLP	Long Live the Farmer Association
CBA	Cost-Benefit Analysis
CDD	Consecutive Dry Days
CEAS	Albert Schweitzer Ecological Center
CIRDES	Centre International de Recherche-Développement sur l'Elevage en Zone Subhumide
CNSF	National Forest Seed Center
ECOWAS	Economic Community of West African States
FAO	Food and Agricultural Organization
FNGN	Fédération Nationale des Groupements Naam
GAP	Good Agricultural Practice
GIC	Green Innovation Center
GII	Gender Inequality Index
GIZ	German Agency for International Cooperation
HDI	Human Development Index
ICCO	International Cocoa Organization
IDR	Institut de Développement Rural
IFAD	International Fund for Agricultural Development
INDC	Intended Nationally Determined Contributions
INERA	Environmental Institute for Agricultural Research
INSD	National Institute of Statistics and Demography
INTERSEB	Interprofession Sésame du Burkina Faso
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
IRSAT	Institute for Research in Applied Science and Technology
JICA	Japan International Cooperation Agency
LGP	Length of Growing Period
MAAH	Ministère del'Agriculture et des Aménagements Hydrauliques
NAP	National Climate Change Adaptation Plan
NAPA	National Adaptation Program of Action
NAR	Natural Assisted Regeneration
NDWS	Number of Days With Moisture Stress
NPV	Net Present Value
NRSP	National Rural Sector Program
PARI	Program of Accompanying Research for Agricultural Innovation
PNDD	National Policy for Sustainable Development
RCP	Representation Concentration Pathway
SAFE	Sasakawa Africa Fund for Extension Education
SCADD	Strategy for Accelerated Growth and Sustainable Development
SNVACA	Systeme National de Vulgarisation et d'Appui Conseil Agricole
SRI	System of Rice Intensification
UNFCCC	United Nations Framework Convention on Climate Change
UO	The University of Ouagadougou
USAID	United States of America Agency for International Development
USDA	United States Department of Agriculture
WAAPP	West Africa Agricultural Productivity Programme

1. INTRODUCTION

Burkina Faso is a landlocked Sahelian country situated in West Africa. Agriculture is integral to its socio-economic development, as a source of livelihoods and national income. However, climate change impacts, such as an increasing prevalence of droughts and floods in the country, have curbed the growth of the agricultural sector. The small-scale farmers who dominate this sector face many challenges in their adaptation and mitigation efforts. As outlined in its National Adaptation Plan, the government of Burkina Faso acknowledges the need for building the nation's resilience against a rapidly changing climate and is working to incorporate climate change in its policies for sustainable economic and social development. This goal is in line with Burkina Faso vision 2025, which aims at transforming the national economy through sustained and inclusive growth.

The German Agency for International Cooperation (GIZ) has commissioned Green Innovation Centers (GICs) in Burkina Faso for the agriculture and food sector as part of its "ONE WORLD – NO HUNGER" initiative. Supported by Burkinabe Ministry for Agriculture (Ministère de l'Agriculture et des Aménagements Hydrauliques, MAAH) the GICs focus on the sesame and rice value chains in the Sud-Ouest, Hauts-Bassins, Boucle du Mouhoun, and Cascades regions (Figure 1). The aim is to improve the availability of inputs while increasing mechanization and access to improved seeds in the prioritized value chains. Particular emphasis has been put on improving sesame productivity by building technical, and technological capacities for production and processing and by facilitating the use of improved varieties (Green Innovation Centre Burkina Faso, 2018). The GIC has promoted interventions in the rice value chain that include the use of climate-resilient, disease-resistant, high-yielding varieties; low emission strategies; reduced use of fertilizers; implementation of the System Rice Intensification (SRI); and use of solar technologies (Green Innovation Centre Burkina Faso, 2018). Measures in both value chains are disseminated through farmer training.

Figure 1. Map of the selected regions



This document presents Burkina Faso's climate risk profile. The aim is to inform value chain stakeholders, policymakers, and the private sector about the climate change risks, vulnerabilities, and opportunities in the sesame and rice value chains in Burkina Faso. This climate risk profile is organized into six sections. The first describes the importance of agriculture to people's livelihoods in the four departments. Section two highlights the policies, strategies, and programs implemented in the three value chains that address climate change, while the third section discusses the governance and institutional resources and capacity. The fourth section discusses the main climatic hazards affecting the three value chains and presents climate modeling results for projected climatic change-related hazards and crop suitability maps. Additionally, it offers an analysis of vulnerabilities and risks posed by these hazards to the respective value chains. The ongoing on-farm adaptation strategies adopted by farmers to cope with these hazards as well as the cost benefit analysis results are discussed in the fifth section. The sixth section provides a synthesis and recommendations.

2. AGRICULTURAL CONTEXT

KEY MESSAGES

- » Agriculture is an important sector in the Burkinabe economy, employing a majority of the work force in the country. The majority of workers in the sector are women.
- » Burkinabe climatic conditions favor livestock and challenge crop production.
- » The sesame value chain is important due to its export earnings, while rice has the potential to generate income and support household food security.
- » Climate change is a major challenge in the sector; its impacts are exacerbated by low input use, high poverty and low literacy rates, and limited access to financial services and extension support.

2.1. Economic relevance of farming

Burkina Faso covers a land area of about 274, 200 km². It traverses the Sudano-Sahelian, Sudanian, and Sahelian climactic zones, and is divided into 13 administrative regions mainly; Cascades, Sud-Ouest, Hauts-Bassins, Centre-Ouest, Centre-Sud, Centre-Est, Est, Sahel, Centre-Nord, Nord, Boucle du Mouhoun, Centre, Plateau-Central, and Ouagadougou; these are further divided into provinces (World Bank, 2011).

Livestock husbandry and crop production play a huge role in the Burkinabe economy. The agriculture sector employs more than 80% of the population and constitutes about 28% of the country's gross domestic product (GDP). Women, who constitute more than half of the labor force in agriculture, produce more than 66% of food consumed in the domestic market (World Bank, 2020). Maize, millet, sorghum, and rice are the main staple crops of the country. As of 2018, the main agricultural exports in terms of export value were cotton (69%), cashew (43%), and sesame (28%).[2] Other important exports include peanut, soy, maize, sorghum, millet, cowpeas, and sugarcane. The livestock sub-sector accounts for about 30% of agricultural GDP, generates notable foreign exchange, and is a main source of food within the country (World Bank, 2017a).

2.2. People and livelihoods

As of 2018, the population[3] was 19.75 million people, with slightly more females than males and a population growth rate of 2.9% (Figure 2). About 70% of the Burkinabe population lives in rural areas.[4] Despite limited resources, Burkina Faso has experienced impressive growth leading to a decline in poverty over the last decade. The biggest challenges to the economy are scarce natural resources, frequent natural hazards, over-dependence of the economy on the agricultural sector, and high levels of insecurity and terrorism. All of these factors have far-reaching effects on most sectors of the Burkinabe economy, especially agriculture.

2 Authors' calculation based on FAOSTAT data available at http://www.fao.org/faostat/en/#data/TP

3 https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&in-f=n&zm=n&country=BFA

4 http://hdr.undp.org/en/countries/profiles/BFA

High poverty, low literacy, and inequalities between urban and rural areas contribute to Burkina Faso's poor performance in global human development indicators. Moreover, most of its indicators are below the Sub-Saharan Africa averages. For example, the country ranked 182nd in the Gender Inequality Index (GII) for 2020, and the Human Development Index (HDI) for 2018. An estimated 41% of the population lives in poverty. The poverty rate is higher in rural areas (47.5%) than urban areas (13.7%) (World Bank, 2017b). Similarly, literacy levels are low, as only 41% of adults (ages 15 and above) are literate. Access to amenities such as electricity is limited: only about 17.5% of the population has access to electricity, and rates are lower in rural areas. Poor access to food translates to poor nutrition. For example, about 20% of the population is under-nourished, while about 28% of the children below five years are stunted.[5]

The Sud-Ouest region, comprising 4 provinces, covers about 16,202 km². The region supports about 795,549 people, which is 4.3% of the country's population. There were slightly more females than males (52% and 48% of the population respectively) as of 2015. Living standards in this region are comparable to those of the whole country. About 69% of the population in the region lives in rural areas. The poverty level is the country's average (41%). Food insecurity is high: households in this region generally spend about 60% of their incomes on food and 55% of all households suffer from food poverty. Nevertheless, the region outperforms national averages when it comes to some nutrition indicators: for example, only 6.2% of children below 5 years are stunted, compared to 28% of the whole country. Literacy level in the region is low (18%) compared to that of the whole country (28%); the youth literacy rate is also low (26.2%). About 71% of households have access to potable water. Given this socio-economic profile, the region's HDI is about 0.385.[6]

The Hauts-Bassins region comprises 3 provinces, covering about 25, 344 Km². As of 2015, the region had a population of about 1,961,204, approximately 11% of the country's population of which 51% were female and 49% were male. An estimated 73% of the population lives in rural areas. The poverty level is lower, at 34.4%, than the national average. Households spend about 44% of their incomes on food, and the level of food poverty was 30%. Stunting and wasting among children below 5 years of age is also low (2.3% and 0.3% respectively). Access to electricity for lighting and portable water is low. Similarly, access to amenities, as measured by the quality of life in the region is low. The region has a HDI of about 0.478, which is almost similar to that of the entire country (0.434).

Boucle du Mouhoun is the third-largest region in Burkina Faso, covering 34,333 km² and divided into 6 provinces. The region had a population of about 1,821,059 in 2015, about 10% of the country's population, with slightly more females than males. About 73% of the population lives in rural areas. Poverty levels in this region are higher, at 60%, than the national average and most of the other regions. Most of the poor people live in the rural areas. Access to amenities is also poor. For example, only 8% of the population have access to electricity for lighting, and just over half (57%) of households have access to potable water. Youth literacy levels in the region is about 32%. Despite the high poverty levels, the proportion of households that are food insecure is lower than national averages, with only about 25% of the households suffering from food poverty, 3% of children under 5 stunted, and less than 1% wasted. The region's HDI of 0.402 is lower than that of the country as a whole.

The Cascades region comprises 2 provinces and covers about 18,424 Km². It is the least populous region in Burkina Faso, representing

5 http://faostat.fao.org/static/syb/syb_233.pdf

6 https://globaldatalab.org/profiles/region/BFAr113/

only 4% of the total population with 739,497 persons in 2015. The proportion of people living in rural areas is smaller (58%) than the national average or the other regions considered in this report. This region is also better off than the rest of the country in most of the development indicators. The regional poverty level is lower (23%); 88% of households have access to potable water and 21% have access to electricity. Youth literacy, though below the national average, is better than the other three regions. 35% of the region's population suffers from food poverty, but the proportion of stunted and wasted children below 5 years is less than 1% each. Despite better access to some amenities and lower poverty levels, the HDI of Cascades stands at 0.444.

2.3. Agricultural activities

Prevailing climatic conditions in Burkina Faso favor livestock production but limit the scope of crop production. Out of 274 million ha, only 121 million ha (44%) are under agricultural production, of which only about 60 million ha (22%) are under arable production. Arable land has expanded by about 21% since 1990, and the expansion has been mostly into lands less suitable for agriculture (World Bank, 2020). Most of the sector is composed of small-scale farmers who own less than 5 ha of land. Cereals, are the dietary cornerstone in the country, take the bulk of the cultivated land. The leading cereals in terms of cultivated land are sorghum (14%), millet (10%), and maize (8%). Cowpeas and cotton take about 7% and 10% of the cultivated land.

The livestock sector is vibrant, with a large livestock population. In 2014[7], there were about 9 million cattle, 23 million ruminants, 34 million poultry and 2 million pigs in Burkina Faso (World Bank, 2020). About 95% of Burkinabe livestock keepers are smallholders. The main livestock products include beef, milk, chicken, and eggs. Beekeeping and fish farming are also present, although less important in the agricultural sector.

Agriculture is the main economic activity in the Sud-Ouest region. The sector employs about 74% of the region's labor force. An estimated 218,767 ha in the region are under food crops, while about 61,233 ha are under cash crops (EPA, 2015). Use of fertilizer is low: only about 13% of farming households use organic manure, while 15.3% use basal, and 12.5% use top-dressing (Holtzman et al., 2013). The main livestock in the region include poultry (1,179,007), goat (447,560), cattle (275,974) and sheep (193, 475) (INSD, 2016).

Both crop production and livestock husbandry play a major role in the economy of the Hauts-Bassins region. Food crops occupy 390,473 ha of land here and 346,018 ha are under cash crops respectively (EPA, 2015). Crop production is mainly small-scale and the use of agricultural inputs is also low. Approximately 12.7% of households in the region use organic manure, 32.8% use basal, and 28% use top dressing fertilizer (Holtzman et al., 2013). The use of field pesticides and herbicides, conversely, is relatively high (63% and 54% of households using each, respectively). Only about 24% of the households use storage pesticides (RGA, 2006-2010). The region supports a large livestock population with 3,052,861 poultry; 1,241,034 cattle; 614,372 sheep; and 587,233 goats (INDS, 2016).

Agriculture is likewise the main economic activity in the Boucle du Mouhoun region. Here, 682,566 ha are under food crops and 331,614 ha are under cash crop production (EPA, 2015). The Boucle du Mouhoun region has the most sesame production in the country. Use of agricultural inputs here is low; with rates of fertilizer standing at 17.6% for organic manure, 20% for basal fertilizers and 15% for top dressing (Holtzman et al., 2013). The use of field pesticides (49%), storage pesticides (19%), and herbicides (16%), is lower than that in Hauts-Bassins but higher than that of Sud-Ouest (RGA, 2006-2010). The livestock herd in the region is also smaller than that of Hauts-Bassins, with 645,582 cattle; 550,096 sheep; 863,129 goats; and 3,007,289 poultry (INSD, 2016).

Agriculture employs about 72% of the population in Cascades. About 122,036 ha and 106,876 ha are under cash and food crops respectively (EPA, 2015). The use of agricultural inputs is low: only about 10% of households use organic manure while 26% use basal and 23% use topdressing fertilizer (Holtzman et al., 2013). Slightly more than half of the households use field pesticides and herbicides, but only about 14% use storage pesticides (RGA, 2006-2010). This region is highly suitable for rice production. Livestock production is also an important activity. The main livestock types are poultry (3,007,289), cattle (543,992 head), sheep (170,540 head) and goats (162,966 head) (INSD, 2016).

2.4. Agricultural value chain commodities

2.4.1. Sesame

Sesame production has been growing in the country since 2008, boosted by rising international prices and increasing international demand (Oxfam, 2018). Sesame is produced mainly as a cash crop in the Boucle de Mouhoun region, and specifically in Kossi Province, where more than half of the country's sesame originates (Oudendijk, 2014). Among the four regions, Boucle de Mouhoun accounts for 40% of national production, followed by the Est (20%), Cascades (13%) and Hauts-Bassins (9%) regions (PARI, 2015).

There are about 1.5 million sesame producers in Burkina Faso, with an annual average five-year production of 200,000 tons (INTERSEB, 2019). Historically, sesame was considered a women's crop in Burkina Faso because its oil was mainly used in meal preparations. But with the development of a remunerative export market, men have come to dominate the value chain, and production has moved onto larger farms. For this reason, women, who constitute of 40% of sesame farmers, are forced to produce on small plots and are mostly involved in low value, labour intense activities such as seasonal collection[8] and cleaning (Gildemacher et al., 2015).

High demand and intense growth in the past decade have created a highly competitive and disorganized value chain. A survey conducted in Kossi Province indicated that the use of agro-inputs among sesame farmers is low. While a majority (58.5%) of sesame farmers use herbicides, fewuse fertilizer (18%), insecticides (21%) and fungicides (26%) (Oudendijk, 2014). Compost is applied to just 17% of the sesame fields in Burkina Faso (Gildemacher et al., 2015). Low input use is connected insufficient farmer knowledge, inadequate finance, and negative farmer perceptions, such as the belief that using herbicides can result in the death of animals.

There is a shortage of certified sesame seeds due to lack of a commercialized distribution system. Gildemacher et al. (2015) note that less than 5% of Burkinabe sesame fields use quality seeds, since most farmers obtain seeds from their individual plots. Notwithstanding, the S42 (white colour), 38-1-7 (cream colour), and 32-15 (white colour) sesame varieties are popular in Burkina Faso (INTERSEB, 2019). Of these, the S42 variety is the best for the international market, thus it has a higher demand (Oudendijk, 2014). The Environmental Institute for Agricultural Research (INERA) works with the union of seed producers to produce certified seedlings. The union sells most of these seedlings to the

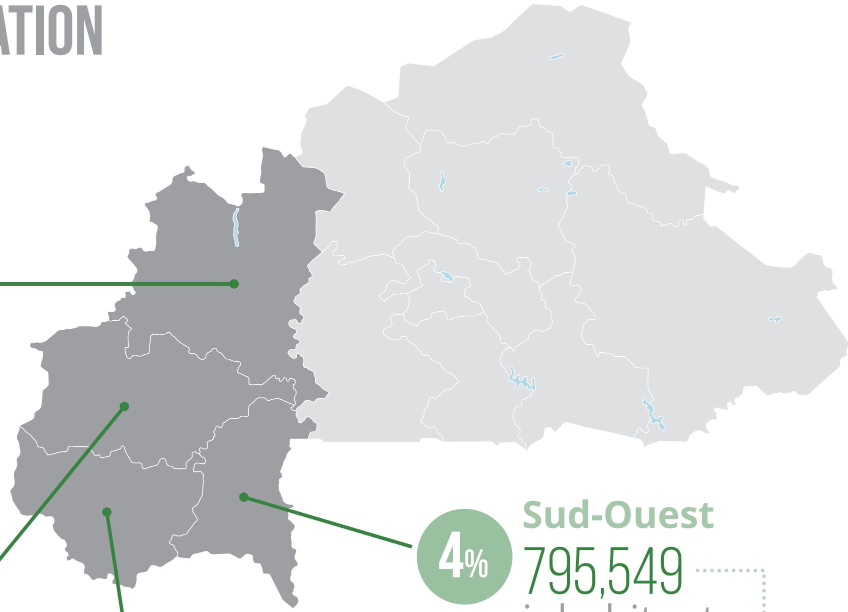
7 Unless stated otherwise, the statistics used in the document are from the housing and population census conducted by the Institut national de la statistique et de la démographie (INDS 2016)

8 Sesame has a collection season which runs for two to three months. Some of the sesame is transported to collection points where large buyers purchase it from.

Figure 2. Livelihoods and agriculture in Burkina Faso

DEMOGRAPHICS

BURKINA FASO'S POPULATION
18,450,494



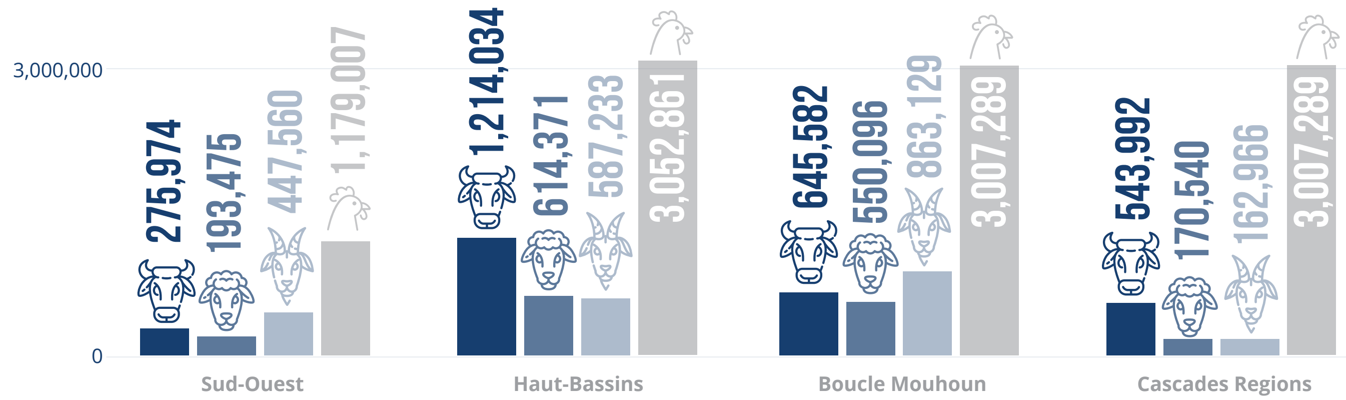
Region	Share of population	Inhabitants	Women	Men	of which are rural
Boucle Mouhoun	10%	1,821,059 inhabitants	51%	49%	73%
Haut-Bassins	11%	1,961,204 inhabitants	51%	49%	73%
Cascades Regions	4%	739,497 inhabitants	51%	49%	58%
Sud-Ouest	4%	795,549 inhabitants	52%	48%	69%

FOOD SECURITY

	Sud-Ouest	Haut-Bassins	Boucle Mouhoun	Cascades Regions
Population suffering from food poverty	55%	30%	25%	35%
% of people undernourished	1.0%	1.4%	7.0%	0.7%
% of household income spent on food	59%	44%	57%	40%
% children stunting	6.2%	2.3%	2.8%	2.4%
% children wasted	1.1%	0.3%	0.2%	0.6%

FARMING & LAND USE

	Sud-Ouest	Haut-Bassins	Boucle Mouhoun	Cascades Regions
% of people employed in agriculture	74%	ND	ND	72%
Total area under cash crops in ha	61,233	346,018	331,614	106,876
Total area under food crops in ha	218,767	390,473	682,566	122,036



AGRICULTURAL INPUTS

Distribution of freshwater resources*

Livestock	165 MILLION M³
Domestic	336.8 MILLION M³
Subsistence	1,289 MILLION M³
Others	4.21 MILLION M³

*National data, not disaggregated

Fertilizers (% of households)

	Sud-Ouest	Haut-Bassins	Boucle Mouhoun	Cascades Regions
Organic manure	13%	13%	18%	10%
Basal fertilizer	15%	33%	20%	26%
Top dressing fertilizer	13%	28%	15%	23%

Pesticides (% of households)

	Sud-Ouest	Haut-Bassins	Boucle Mouhoun	Cascades Regions
Field pesticides	20%	63%	49%	54%
Storage pesticides	9%	24%	19%	14%
Herbicides	6%	54%	16%	50%

ACCESS TO BASIC NEEDS

	% of the population suffering from absolute poverty	% of households with access to electricity for lighting	% of households with access to potable water	Youth literacy rate (15-30 years)
Sud-Ouest	42%	7%	71%	26%
Haut-Bassins	34%	33%	66%	41%
Boucle Mouhoun	60%	8%	57%	32%
Cascades Regions	23%	21%	88%	38%

ND: Not Disclosed

government, which then sells them at subsidized prices to farmers through organized groups. The remaining certified seedlings are sold by the union directly in the market. Development programs and projects also take part in seed distribution.

Before 2010, sesame was primarily cultivated for consumption and surpluses were sold on a small scale. Presently, it is mainly produced for the export market, with some sold in the local market. Almost 90% of sesame produced is exported to Singapore, Japan, Ghana, China, and Togo (INTERSEB, 2019); only 10% is sold locally (Gildemacher et al., 2015). Production for export has been aided by a five-fold expansion in the area under sesame production. Sesame production has higher profit margins because it is less labour intensive, requires low investment, and the crop is highly tolerant to drought (PARI, 2015).

Sesame farmers primarily sell sesame to local brokers (75%), followed by farmers' groups and cooperatives (11%) and village buyers (5%). The main value-added product from sesame is sesame oil. However, sesame processing happens on a minor scale, producing a negligible amount that barely serves the local and foreign market demand (Gildemacher et al., 2015). It is necessary to invest in the local production of sesame oil. Other value-added products from sesame are sesame paste (tahini) and hulled white sesame seeds used for baking.

Sesame farmers have support from government extension agents under the Ministry of Agriculture, who offer training on good agricultural practices (GAPs). This support has led to higher yields, especially in the Cascades and Est regions. However, finance remains a major obstacle in the sesame value chain, especially among sesame collectors. Sesame collectors mainly rely on intermediate international traders for financing, but there are still inadequate financial resources to facilitate collection (Gildemacher et al., 2015).

2.4.2. Rice

Rice is an important staple and cash crop in Burkina Faso. The Bagré (in the Central-Est region), West (in the Hauts-Bassins and Cascades regions, and Sourou Province (in the Mouhoun region) are the major rice producing areas in the country (PARI, 2015). Together, the West and Bagré areas contribute to almost half (at 26% and 23%, respectively) of the national rice production (Rogers, 2012a).

Production is fragmented and mainly practiced on a small-scale level. There are about 100,000 small-scale producers spread across the three rice-producing areas. They operate on plot sizes ranging from 0.5-1 ha, with an output of 2 metric tons/ha. There are, however, a few farmers who own almost 100 ha (PARI, 2015). Rice is intercropped with groundnuts, sorghum, millet, maize, and cotton. According to Rogers (2012a), 50% of Burkinabe rice is grown under rain-fed irrigation, and 50% under water containment or full irrigation. The latter systems give relatively higher yields, of which up to 80% of the output can be sold. In contrast, rice produced under rain-fed irrigation is mostly for consumption.

Rice producers in Burkina Faso are constrained by inadequate finance. Rogers (2012b) notes that farmers lack cash to purchase quality seeds and fertilizer or to implement crop protection. Additionally, they are unable to access mechanization to improve on production and harvesting. For this reason, most of the harvesting is done manually. Rice processors lack capital which limits their processing and storage capacity. Most of the rice is processed in small, local mills and is mainly used for household consumption. The remaining rice is exported (usually through informal chains to Mali) as paddy rice for further processing. Women's groups play a significant role in the local processing of rice through parboiling and selling it in the local market.

Rice production in Burkina Faso can only meet 47% of the population's demand (PARI, 2015). According to Grow Africa (2018), Burkina Faso's rice consumption stands at 590,000 metric tons, more than twice the local production of 226,000 metric tons. Thus, for the past 5 years, the country has relied heavily on rice imports (which account for 60% of the supply) from countries such as Taiwan.

Almost 59% of the population prefers imported rice and 26% prefer value-added local parboiled rice. Local white rice is poor in quality and high in price, despite frequently containing broken pieces and foreign matter contamination. Imported rice is preferable because it is old and dry, which means it has higher volume (by 30%) after cooking (Rogers, 2012a). Consumers believe that this reduces the price by the same percentage, thus decreasing the competitiveness of local rice on a price-per-kg basis. Large traders are mainly involved in the importation of rice, a few however sell to urban consumers. Through the National Company of Food Security Stock Management (SONAGESS), the government is the main promoter and distributor of imported rice. The government is working towards expanding and improving local rice production to reduce imports, including a plan to expand irrigated land under rice from 1,800 ha to 15,000 ha (PARI, 2015).

2.5. Agricultural sector challenges

Agricultural production in Burkina Faso is characterized by dependence on rainfall, small farm plots, and low input use (Sogue and Akcaoz, 2018). As a landlocked country situated in the Sahel region, Burkina Faso is increasingly vulnerable to seasonal and annual climate variability. Therefore, rain-fed farming renders agriculture particularly sensitive to climate changes. Heat stress, excessive rainfall, flash floods, and prolonged droughts are the climate risks and hazards that pose the most significant threats to crop and livestock productivity in the country. In addition to climatic changes, the agriculture sector's development is constrained by a host of other factors including persistent high poverty rates among farmers; gender inequalities in farming; inadequate institutional policy support; and lack of finances to champion national adaptation efforts. These factors can curtail farmers' efforts and ability to respond or recover effectively, locking them in precarious situations.

Access to improved, climate-resilient, high-yielding, disease-resistant, or short maturing seeds is extremely limited for both sesame and rice. On one hand, many farmers are impoverished and therefore lack capital to buy improved seed. On the other, commercial seed multipliers lack an efficient seed distribution system that would facilitate access to high quality certified seeds in local markets (Gildemacher et al., 2015). For this reason, many farmers use their own seed to farm.

Financial services like crop insurance and access to credit are limited by the increasing prevalence of climate hazards and the high-risk nature of farming. The predominance of small-scale, subsistence, and diverse farming systems makes the design and implementation of such financial products difficult. When they are available, they lock out a conspicuous number of women farmers due, due to their lack of control over productive resources, like land, required to secure insurance products. (Sogue and Akcaoz, 2018). This further demonstrates how the social norms of gender inequality reinforce disparate access and control to productive resources (OXFAM, 2011).

Limited access to information and weak extension support services further challenge adaptation efforts in Burkina Faso (USAID, 2014). These gaps lead to an inadequate knowledge base on GAP, varietal improvement, and disease management. Consequently, the less contact farmers have with technical extension services, the lower their chance to be exposed to new, improved strategies and technologies. An absence of climatic monitoring and communication services impedes critical decision-making on and off farms (USAID, 2012). The insufficiency of information and lack of open communication between the actors and credit institutions in promoting the agricultural sector also contribute to farmers' vulnerability to climate risks, especially in the sesame value chain.

Poor market infrastructure and price volatility intensifies the vulnerability of farmers due to reduced incomes. The disharmony between producers, processors, and exporters makes for a fragmented system with many uncontrolled actors. Inadequate infrastructure, e.g. postharvest storage or poor roads, and restrictive trade policies disconnect farmers from markets. (IMCG, 2018).

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3. POLICIES, STRATEGIES AND PROGRAMS ON CLIMATE CHANGE

KEY MESSAGES

- Burkina Faso lacks a specific, overarching national policy or strategy to tackle the impacts of climate change.
- However, climate change has been incorporated into national adaptation plans and programs, that aim to manage its impacts.
- Presently, the National Adaptation Program of Action and the National Climate Change Adaptation Plan guide the implementation of climate change strategies.

Although Burkina Faso lacks a national climate change policy or strategy, the country is working towards developing national adaptation plans and including climate change in different policies. While most of them address the interlinked challenges stemming from agriculture and climate change, others have specific agendas. Crawford et al. (2016) note that the existing plans have failed to prioritize aspects of irrigation and research and development in their planning process.

The National Adaptation Program of Action (NAPA 2007) has been key in identifying urgent needs and actions that can help communities cope with the impacts of climate change. NAPA focuses on four vulnerable sectors of the economy (agriculture, forestry, water, and pastoralism); therefore, the development actions in these arenas guided the planning process. Based on NAPA projects, the National Climate Change Adaptation Plan (NAP 2015) was developed with the dual objectives of reducing the vulnerability of social and economic systems to climate change and integrating climate change into present and future policies and strategies. Adaptation priorities have been articulated further in the Intended Nationally Determined Contributions (INDC) submitted in 2015 to the United Nations Framework Convention on Climate Change (UNFCCC). The INDC reflect the content of the NAP and Burkina Faso's framework for sustainable land management. It therefore provides an operational action plan for climate change adaptation in the agricultural sector.

Climate change has also been widely integrated into policies, strategies, and plans at the national level. For example, in the Strategy for Accelerated Growth and Sustainable Development (SCADD 2011-2015), climate change is recognized as an inhibitor of economic growth through its impact on the agricultural sector. One of SCADD's objectives is to achieve environmental sustainability so as to minimize agricultural losses. The National Policy for Sustainable Development (PNDD 2013) also recognizes the impact of climate change on the country as a whole and is intended to replace SCADD upon its expiry. Other policies that recognize climate change as a potential risk include the National Rural Sector Program (NRSP 2011-2015), the National Policy for Food Security and Nutrition, the National Action Plan for Integrated Water Management, the National Program for the Provision of Drinking Water, and the Sanitation and the Forest Investment Program.

4. GOVERNANCE, INSTITUTIONAL RESOURCES AND CAPACITY

KEY MESSAGES

» Burkina Faso has a strong private and public sector engagement in the agricultural sector generally, including in the rice and sesame value chains.

» Farmers have benefited from services offered by organisations in both sectors that aim to build their resilience to climate change.

» There is, however, need for a strategic collaboration between institutions for the effective implementation of climate change initiatives.

A wide array of actors and institutions must be engaged to ensure food security, profitable farming, and climate-resilient livelihoods in Burkina Faso. These include governmental institutions, non-governmental organisations (NGOs), civil society, the private sector and development partners. Depending on the roles and responsibilities undertaken by each institution, coordination and collaboration are necessary to avoid conflicts and unnecessary duplication of efforts and to build synergy.

Agricultural research and development are fundamental to fostering innovation and productivity. Among the fifteen existing public agencies that conduct agriculture research, INERA is the largest (CORAF, 2020). It focuses on the development of resilient varieties that are adapted to environmental conditions and aligned with consumer needs in sub-regional and international markets. It works closely with The West and Central African Council for Agricultural Research and Development (CORAF), an international non-profit association working to enhance prosperity, food, and nutrition security in West and Central Africa. Other invested government agencies include the Institute for Research in Applied Science and Technology (IRSAT), which is located within the Ministry of Agriculture and is in charge of agricultural research and extension focusing on rice and sesame production. It also focuses on technology development to support the mechanization and transformation of food products (IMCG, 2018). The National Forest Seed Center (CNSF) focuses on forestry research. Academic and nonprofit agencies supporting agricultural research in Burkina Faso include the University of Ouagadougou (UO), the Association for the Promotion of Livestock in the Sahel and the Savanna (APESS), and the Albert Schweitzer Ecological Center (CEAS) (CORAF, 2020). The West Africa Agricultural Productivity Programme (WAAPP), aimed at bolstering farmers' resilience through funding research and extension work, has made major contributions to the development and use of improved technologies and increasing the engagement of women and youth in the sesame and rice value chains.

Agriculture extension services and advisories in Burkina Faso are provided through decentralized systems (GFRAS, 2020). The Ministry of Agriculture, Water, and Fishery Resources, for example, works through the Regional Directorate for Agriculture, Water, and Fisheries and the Systeme National de Vulgarisation et d'Appui Conseil Agricole (SNVACA). Some research institutes also have the capacity to offer extension services, including INERA, the Centre International de Recherche-Développement sur l'Elevage en Zone Subhumide (CIRDES), the Agency for the Promotion of Small- and Medium-Sized Agricultural Enterprises and Handicrafts (APME), and the Institut de Développement Rural (IDR). Non-state actors include Sasakawa Africa Fund for Extension Education (SAFE) and Long Live the Farmer Association (AVLP), while farmer cooperatives include the Association National d'Action Rurale (ANAR), and the Federation Nationale des Groupements Naam (FNGN), who play key roles in increasing the access of farmers' and producers' groups to trainings and services (GFRAS, 2020).

Regional and international development partners realize the importance of the rice value chains for the Burkinabe economy, livelihoods, and food security. Therefore, they have developed numerous projects and programs to sustainably improve productivity and profitability in these value chains. The rice value chain benefits from the Economic Community of West African States (ECOWAS), which finances rice development projects to ensure self-sufficiency by 2025. The Africa Rice Research Center (Africa Rice) supports the national agricultural research system and plays an important role in advancing the rice value chain in Burkina Faso (Fall, 2016). BMZ, CORAF, the Food and Agriculture Organization (FAO), GIZ, the European Union, the International Fund for Agricultural Development (IFAD), the International Rice Research Institute (IRRI), the Japan International Cooperation Agency (JICA), and the United States Agency for International Development (USAID) are among the key international partners working to enhance rice farmers' resilience to climate change. Scaling up the system of rice intensification (SRI), promoting improved rice varieties, enhancing use of good agriculture practices, improving post-harvest handling and processing, boosting farmers' incomes through increased to markets represent major interventions in the rice value chain.

Likewise, regional and international organisations provide support to Burkinabe sesame production. Sesame actors benefit from capacity-building initiatives aimed at enhancing their efficiency and improving competitiveness along the value chain. The international partners supporting such initiatives include BMZ, FAO, the Swiss development corporation HELVETAS, the International Cocoa Organization (ICCO), the KIT Royal Tropical Institute, and the United States Department of Agriculture (USDA). As with rice, the promotion of new and improved varieties, infrastructure improvements, and the promotion of appropriate post-harvest practices and market-oriented technologies are vital for the transformation of the sesame sector.

5. CLIMATE CHANGE-RELATED RISKS AND VULNERABILITIES

KEY MESSAGES

- The impact of climate change in Burkina Faso varies regionally. Nonetheless, droughts and floods are the main hazards to the rice and sesame value chains.
- Historic and future trends show that climate impacts will affect productivity.
- Perceptions on climate change among farmers in Burkina Faso vary, indicating the need to interlink local and scientific knowledge.

5.1. Farmers' perceptions on climate change

Farmers' perceptions about the causes and effects of climate variability depend on cultural beliefs, experiences, and geographical location (Callo-Concha, 2018). For instance, farmers in the Sahelian climatic zone have noticed an increase in the intensity of rainfall over time, while those in the Sudanian-Sahelian zone have noticed a decrease in the rain. However, across climactic zones, most (95%) farmers have noticed an increase in temperatures and dry spells in the past 10-20 years' intensity (Alvar-Beltrán et al., 2020). Farmers also report that rainfall and temperature have varied widely over the same time period.

Due to these erratic conditions, indicators traditionally used to predict weather no longer work (Kima, 2015). Thus, farmers can no longer accurately predict the exact date to plant or adaptation strategy to use, despite receiving climate information from various channels. Safiétou et al. (2014) show that about 55% of farmers receive climate information from radio and television, while the remaining 45% receive climate information from other channels such as agricultural technicians and relatives. Whether farmers actually consider the information they receive from the different channels in their production plans and decisions is however an empirical question.

Farmer's perceptions of the causes of climate change also vary. Some believe that the changes in climate are caused by human activities such as deforestation and burning vegetation (Callo-Concha, 2018). Others, however, believe that the changes are a punishment from angered ancestors (Safiétou et al., 2014). These disparities in understanding point to the need for more sensitization and awareness creation regarding climate change and its implications. There is also an imperative to integrate scientific knowledge with indigenous knowledge for a full understanding of climate change.

Despite varied perceptions regarding climate change and its causes, there is a consensus on its implications. Farmers report reductions in livestock and crop productivity, decreasing water availability, a decline in pastures, increases in incidences of crop and livestock pests (for example, tse tse flies) and diseases, and increases in the mortality rate of livestock. These consequences have had clear impacts on vulnerable households. For example, loss of productivity leads to a decline in income, potentially rendering many households incapable of sustaining their livelihoods. Conflicts between crop and livestock farmers are becoming increasingly frequent due to the scarcity of resources such as pasture and water (Kima et al., 2015).

5.2. Climate change and variability: historic and future trends

Burkina Faso is divided into three main climatic zones, each with a different annual rainfall. The Sahelian Zone has an annual rainfall of about 600mm; the Sudanian-Sahelian Zone sees rainfall averages 600-900mm per year; and rainfall averages in the Sudanian Zone are 900-1200mm yearly (World Bank, 2011). All three zones experience distinct wet and dry seasons, although their length varies with the climatic zone from a short, 2-month wet season in the Sahelian Zone to 6 months in the Sudanian Zone.

The four districts under consideration in this report are in the Sudanian Zone and are at risk of increasing heat and moisture stress. Our analysis focuses on drought risk, measured by consecutive dry days (CDD); heat stress, which is indexed by the number of days with temperatures above 35°C (NT35); flooding risk (using the 95th percentile and maximum 5-day running average of precipitation); moisture stress, indicated by the number of days with moisture stress per season (NDWS); and length of growing period (LPG). For convenience, we divide the year into two seasons corresponding to the first and second half of the calendar year. In general, the first half of the year corresponds to hotter and dryer weather patterns, while the second half of the year is characterized by cooler temperatures and increased precipitation.[9]

Historic[10] data from 1985-2015, and climate projections[11] indicate that heat and rainfall variations are the primary climate risks in the Cascades region. The analysis shows that the first season, particularly in the months of January, February and March, is hotter and drier than the second, particularly in July, August, and September. The average number of CDD, which is a proxy for drought risk, has experienced profound fluctuations, with the number of CDD doubling in the future (Figure 4). The annual average number of days with moisture stress has remained relatively stable at 130 per year, but future trends show a likely increase of the moisture stress days to 140 days on average. The maximum five-day running average of precipitation (P5D), a proxy for flood risk, shows an increasing trend from 19mm in the past to 27 mm in the future (Figure 5). The combination of these indicators has implications on crop production; in combination, they can be used to estimate the LGP. Our analysis shows that future LGP is likely to reduce from its historic annual average of about 132 days to about 100 days per year (see Figure 6).

In the Boucle du Mouhoun region, climate projections show an increase in CDD and risk of floods and a decrease in the LGP. Historically, January, February, and March are the driest and hottest months; July, August, and September are the wettest and coldest (Figure 3). In this region, the average of CDD is likely to increase to 23 days in the future from its historic average of 13 days (Figure 4). Future flood risk shows a similar trajectory, since average rainfall is likely to increase from a P5D average of 16mm to 23mm (Figure 5). These climate effects are projected to have a drastic effect on the LGP, reducing it from 102 days to about 68 (Figure 6).

Likewise, the Haut-Bassins region is facing increases in heat and moisture stress as well as flood risk. The number of CDD is likely to increase from their historic annual average of 12

9 https://climateknowledgeportal.worldbank.org/country/burkina-faso

10 The historical precipitation and temperature trends were analysed using data from CHIRPS (https://www.chc.ucsb.edu/data/chirps), and CHIRTS (https://www.chc.ucsb.edu/data/chirtsdaily)

11 The future projections are an ensemble of downscaled CMIP5 products described (Navarro-Racines et al 2020).

days per year to about 23 days (Figure 4). The NDWS is also likely to increase from 107 days per year to 119, while the number of days with a maximum temperature of 35°C or more is likely nearly double from 57 days per year to 112 days. Flood risk is also projected to increase from a P5D value of 19 mm to 26 mm (Figure 5). In combination, these changes are likely to reduce the LGP from 124 to 89 days (Figure 6).

In the Sud-Ouest region, flood, heat, and drought indicators are all projected to increase from their historic averages. The number of CDD is likely to double to 20 days from a historic average of 11 (Figure 4). The NDWS is likely to increase from 98 to 110 days a year and the number of days with temperatures more than 35°C is likely to double from 44 days to 89 days. Flood risk is also likely to increase from the historic P5D of 18 mm to 26 mm every year (Figure 5). Lastly, the length of growing period is likely to fall from 126 days to 97 days (Figure 6).

5.3. Crop suitability analysis

The discussed climate variation and changes have implications for the general suitability of rice and sesame in their respective districts. In this section, we discuss how climate variation and change is affects the suitability of rice and sesame now and in future projections.

Rice suitability presently varies widely across the four districts. About 75% of the Cascades, 25% of Haut-Bassins, less than 5% of the Sud-Ouest, and none of the land in Boucle du Mouhoun region is highly suitable for rice (Figure 7). 25% of the Cascades, 75% of Haut-Bassins, over 95% of Sud-Ouest, and about 20% of the Boucle du Mouhoun region is moderately suitable for rice.

Future rice suitability under RCP 8.5 increases in Cascades and increases then decreases in the other regions by 2030 and 2050. The entire area in Cascades is likely to be

Figure 3. Historical monthly mean temperature and precipitation (average of last 30 years) for the Boucle du Mouhoun region in Burkina Faso. Bars represent total monthly precipitation, whereas lines represent maximum (red line) and minimum (blue line) monthly mean temperatures.

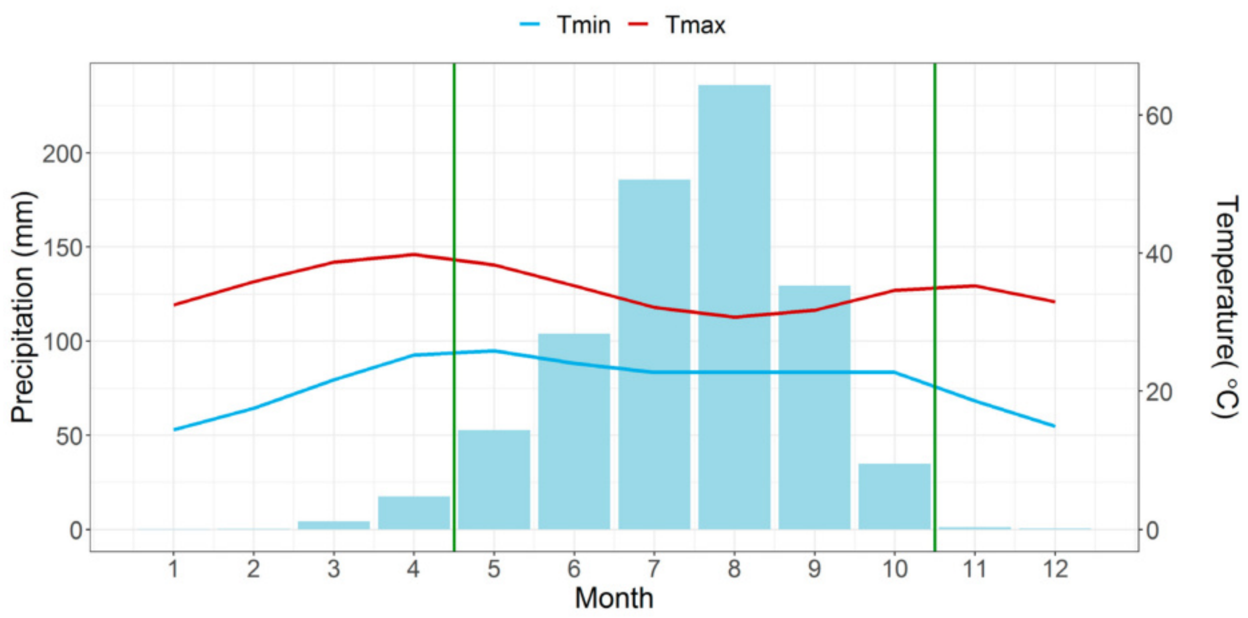


Figure 4. Historical (left), and future projected (center) and projected change (right) for the maximum number of consecutive dry days within the year(all year) (average of last 30 years) for Sud-Ouest, Hauts-Bassins, Boucle du Mouhoun, and Cascades Regions of Burkina Faso

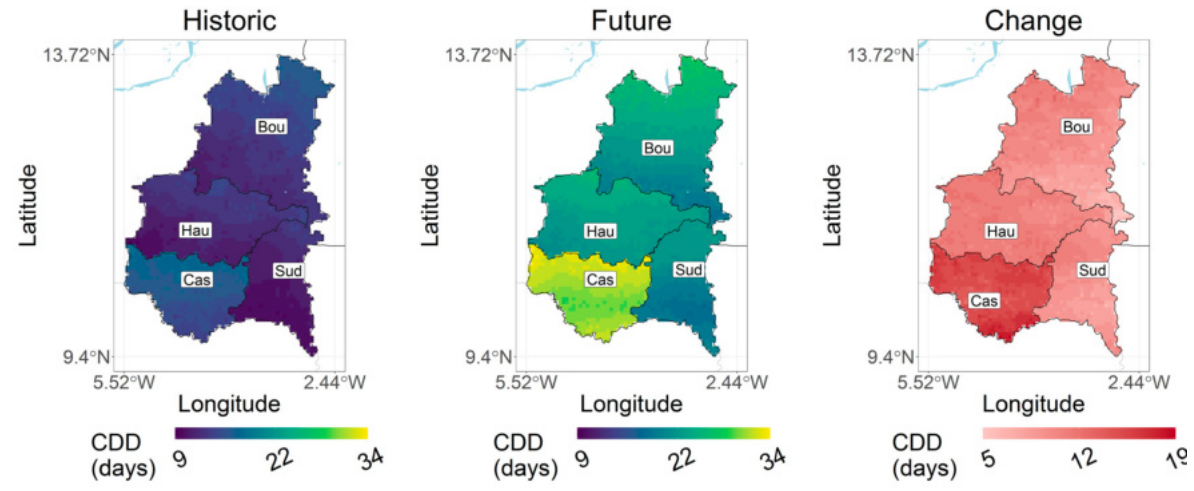


Figure 5. Historical (left), and future projected (center), and projected change (right) for the maximum 5-day running average precipitation in millimetersm (average of last 30 years) for for Sud-Ouest, Hauts-Bassins, Boucle du Mouhoun, and Cascades Regions of Burkina Faso

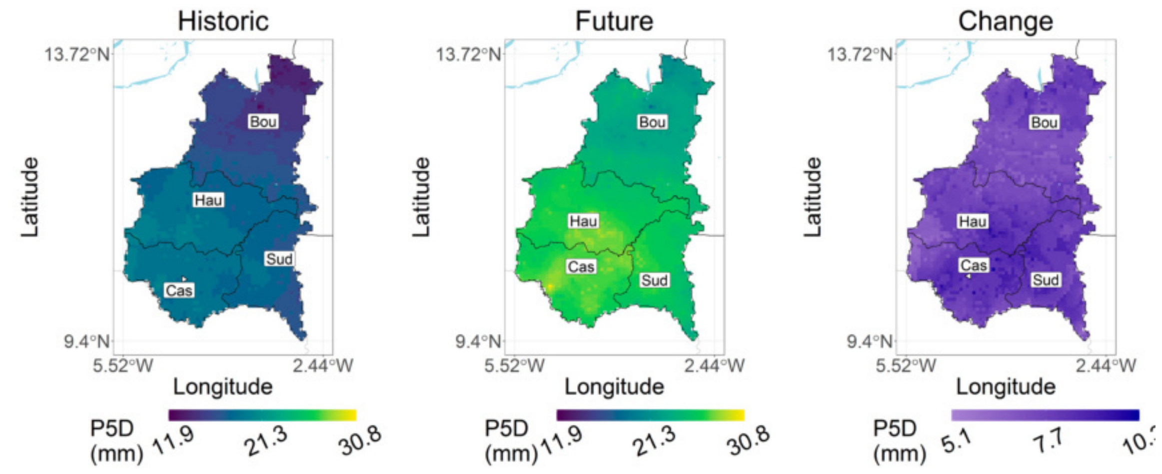


Figure 6. Historical (left), and future projected (center), and projected change (right) for the length (in days) of the growing season (average of last 30 years) for Sud-Ouest, Hauts-Bassins, Boucle du Mouhoun, and Cascades Regions of Burkina Faso

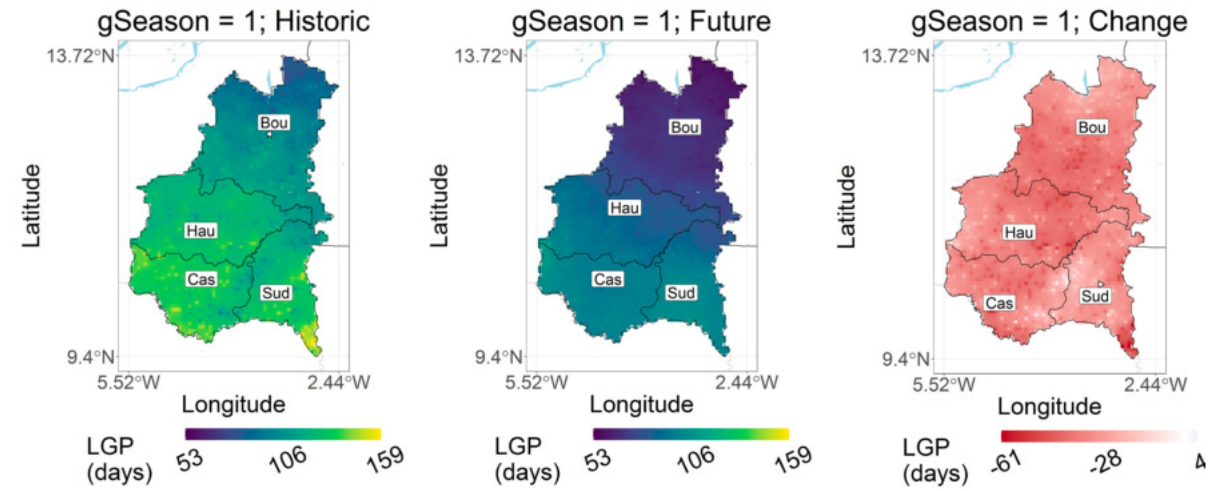


Figure 7. Historical and future (scenario RCP 8.5, periods 2030 and 2050) suitability of rice production in Sud-Ouest, Hauts-Bassins, Boucle du Mouhoun, and Cascades Regions of Burkina Faso

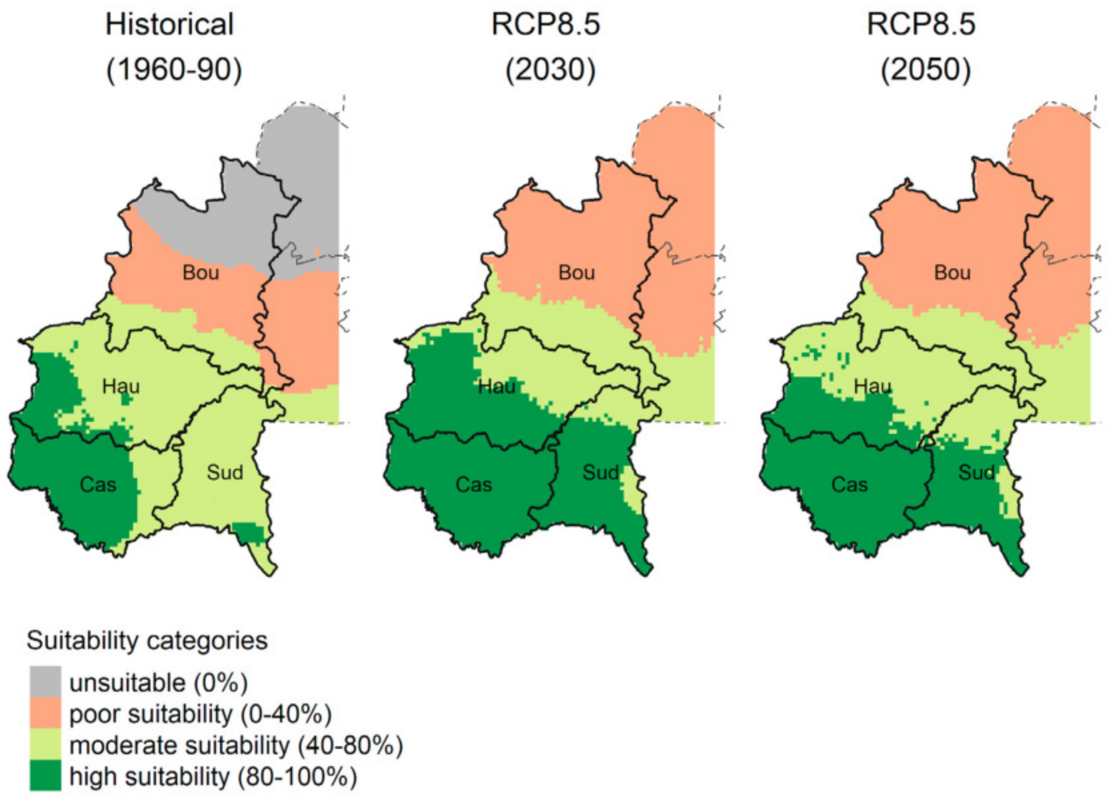
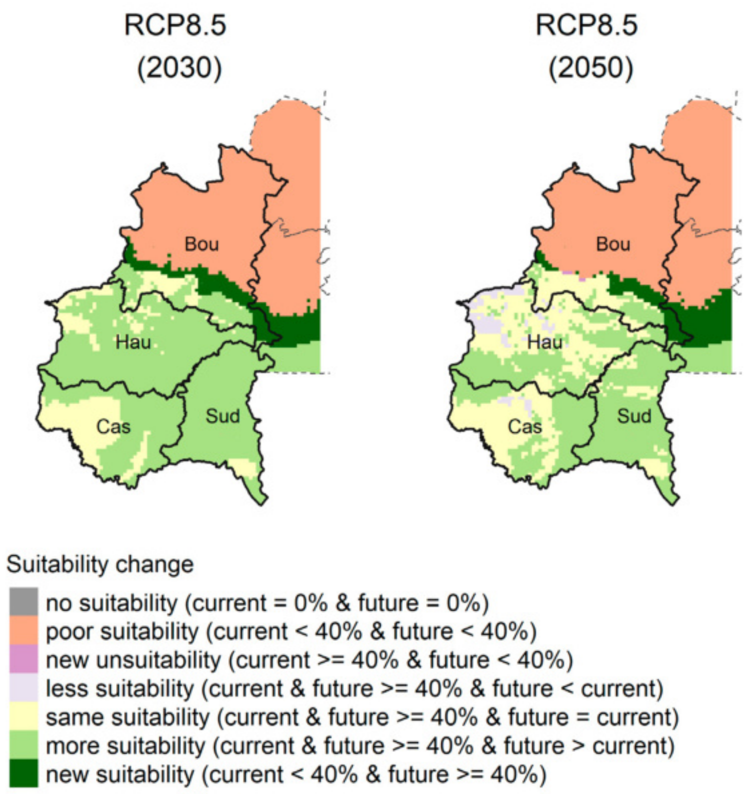


Figure 8. Suitability change of rice production in Sud-Ouest, Hauts-Bassins, Boucle du Mouhoun, and Cascades Regions of Burkina Faso



suitable for rice by 2030 and 2050. While areas of high suitability are projected to increase in Haut-Bassins (by about 40%) and Sud-Ouest (by about 70%) by 2030, suitable areas then decrease 25% and 13%, respectively, by 2050 (Figure 8).

Historically, sesame suitability shows uniformity across the four districts. The Cascades, Haut-Bassins, Sud-Ouest and Boucle du Mouhoun region are highly suitable for sesame, recording a 100% suitability (Figure 9).

Future suitability analysis under RCP 8.5 shows that by 2030 the four regions will maintain higher suitability for sesame. By 2050, the trend of high suitability will persist in the Cascades, Haut-Bassins and Sud-Ouest regions. However, the suitability of sesame in Boucle du Mouhoun region will reduce by almost 40% by 2050, hence becoming moderately suitable for sesame production (Figure 10).

5.4. Climate vulnerabilities across agriculture value chain commodities

Sesame and rice farmers are the most vulnerable actors in these agricultural value chains. Dependence on rain-fed agriculture leaves Burkinabe farmers exposed to frequent droughts and floods, the most detrimental hazards for the rice and sesame value chains. Climate impacts at the on-farm production stage can result in reduced, lower-quality yields, which in turn causes food insecurity and poor incomes. Burkinabe smallholders operate in a context where underlying issues increase their vulnerability, including high poverty levels, poor access to climate information and resources, and a lack of practical skills and knowledge on proper crop management practices that would enable them to better respond to climate shocks.

5.4.1. Rice

Rice requires about three times more water than other cereals such as maize and wheat. These water requirements render rice sensitive to erratic rainfall and temperature fluctuations in general, but sensitivity depends on the production system. Irrigated rice is less affected by the vagaries of climate due to the availability of water. However, in Burkina Faso, rice cultivars are usually grown under the traditional flooding system, which is highly vulnerable to water stress.

Accordingly, drought is the most serious climate risk for rice. Drought causes soil water deficits that lead to moisture stress, which affects proper growth and development of rice, for example, leading to a reduction in plant height or number of tillers (Sangare, 2018). Insufficient water supply contributes to poor flower production and grain filling, which delays maturity and reduces the quality and quantity of rice yields. The interaction of drought with other risks like high temperatures can severely affect rice by increasing evapotranspiration, thus interfering with critical rice morphological and biochemical stages (Van Oort P.A.J., Zwart SJ. 2017).

While flooding can replenish groundwater reserves, prolonged floods are detrimental to rice production. Flooding can be beneficial as it recharges groundwater and water sources and promotes fish farming alongside rice production. However, prolonged flooding can severely affect rice production. Too much water affects the flowering and fertilization stages. Rice plants lose color and become white with brown leaves and the plants become elongated and weak. Excess water increases the incidence of pests like Ufra nematodes in flooded fields. Soil erosion becomes common, contributing to nutritional deficiencies in the rice plants, ultimately affecting the quality of the rice grains. These progressive consequences can lead to reduced yields and, in severe cases, total crop loss. Inevitably, the farmers experience total crop losses that exacerbate existing food insecurity and poverty challenges (Sangare, 2018).

Figure 9. Historical and future (scenario RCP 8.5, periods 2030 and 2050) suitability of sesame production in Sud-Ouest, Hauts-Bassins, Boucle du Mouhoun, and Cascades Regions of Burkina Faso

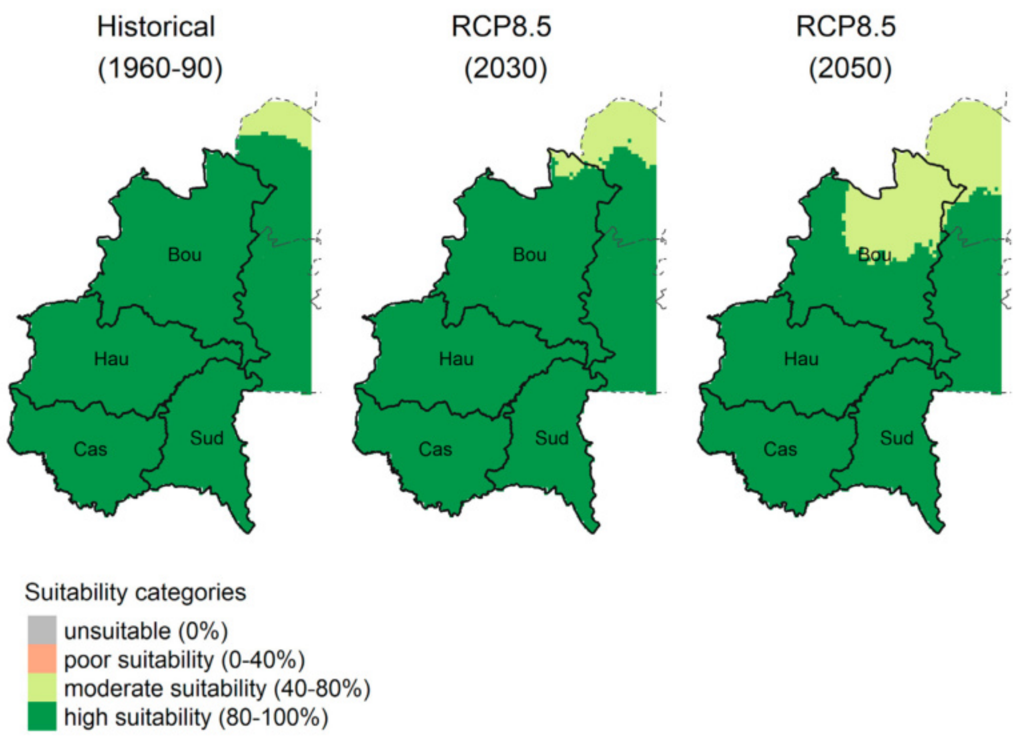
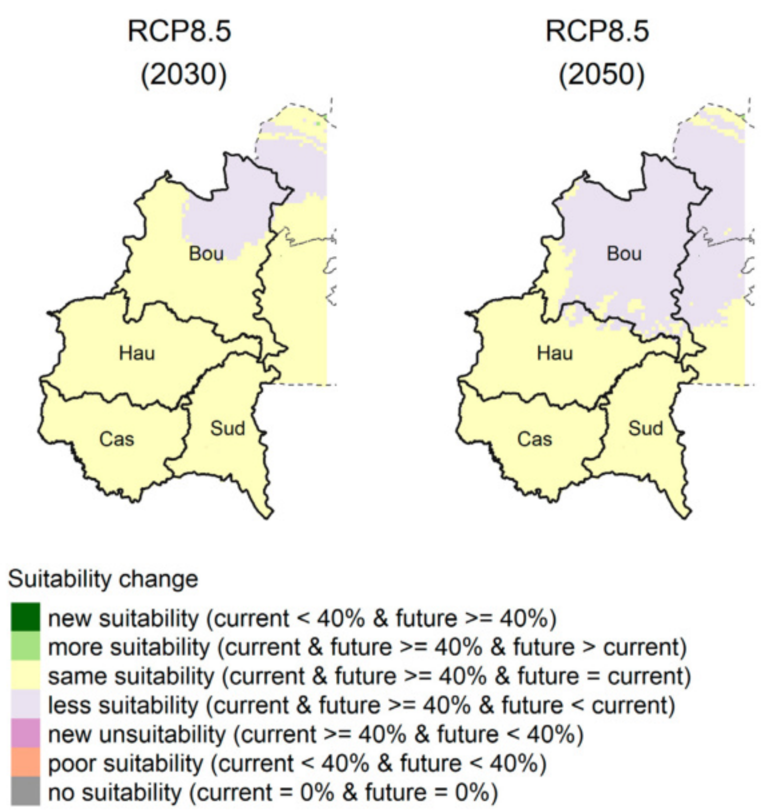


Figure 10. Suitability change of sesame production in Sud-Ouest, Hauts-Bassins, Boucle du Mouhoun, and Cascades Regions of Burkina Faso



Heavy floods in Burkina Faso have displaced people, destroyed infrastructure like roads, increased incidences of human diseases like malaria and killed people. In 2016, floods destroyed the Bogandé Dam, which was used for irrigation of rice and vegetable crops, affecting the rice harvest.[12] In 2020, floods resulted in fatalities and damage of structures, as in the case of the heavy rains that swept away a bridge and disconnected Marabagasso Village from the city of Bobo Dioulasso, destroying shelters and limiting access to basic needs like water and food in Kongoussi, Pensa, and Barsalogho.

5.4.2. Sesame

Sesame will tolerate minimal precipitation and the most degraded soils. It is traditionally cultivated throughout Burkina Faso, in both the dry regions (e.g., Sahel, North, and Centre-North) and wet regions, including the Cascades, Hauts-Bassins, South-West, and Boucle du Mouhoun regions (FAO, 2014). Sesame cultivation does not require irrigation as the plant can withstand rainfall deficits. Some farmers therefore use sesame for crop diversification as a strategy to reduce their vulnerability to drought.

However, sesame's tolerance depends on its developmental stage. Interestingly, although drought is detrimental in general, dry spells are associated with low incidences of sesame phyllody, a vector-borne disease (Cagirgan et al., 2013). Moisture stress can affect critical radical and shoot development processes and the reproduction stage, consequently interfering with proper seed development (Bahrami et al., 2012). Moreover, prolonged, severe drought affects the number of capsules per plant and reduces grain yield and quality (e.g., low oil and protein content) (Bhuyana et al., 2019). In combination with other climate events like extremely high temperatures, moisture stress can contribute to plant dehydration and soil toxicity, resulting in severe yield reductions (Komivi et al, 2019).

Sesame is susceptible to extreme rainfall and floods. Prolonged flooding induces chlorosis and floral abortion, ultimately causing stunted growth and reducing the number of leaves and seeds per plant (Mensah et al., 2006). These effects reduce the time to maturity. Waterlogging, especially at the vegetative, flowering, seed filling, and ripening stages, considerably decreases yields and quality of capsules (Sarkar et al., 2016). Moreover, the secondary effects of floods, such as soil erosion and nutrient leaching, contribute to soil degradation. In addition to damaging sesame plants, excess rainfall increases production costs due to the laborious nature of draining waterlogged fields and increased demand for water tolerant or resistant sesame varieties. Poor qualities and quantities ultimately affect final products and market prices for the crop itself and for value-added commodities.

12 http://www.braced.org/fr/news/i/?id=23e96ca6-7fa8-41ca-8913-52081ce8a941

6. ADAPTATION TO CLIMATE CHANGE AND VARIABILITY

KEY MESSAGES

- » Burkinabe farmers currently implement traditional and climate-smart adaptation strategies.
- » Most of these strategies have been introduced through collaborations between the government and development organisations.
- » Stakeholders in the rice and sesame value chains rank improved varieties, alternate irrigation, organic fertilizers, rice intensification systems, and water collection systems as the best strategies to cope with floods and drought.

6.1. On-farm adaptation strategies

6.1.1. Sesame

Farmers in Burkina Faso already have adaptation strategies to cope with climate variability in sesame production. Many sesame farmers routinely obtain sowing seeds from their own plots. This promotes mixtures of genetic compositions because sesame is a cross-pollinating species; one farmer's crop is influenced by neighboring crops (Gildemacher et al., 2015). Farmers have been implementing soil and water conservation practices to increase water infiltration, which reduces water stress during dry periods and soil erosion during flooding. These include composting; the use of organic manure; building barriers like stone bunds and digging zai pits or half-moons to capture water; the application of natural assisted regeneration (NAR); mulching; and planting grass strips and wind screens (Savadogo et al., 2011). Some farmers practice re-sowing, adopt new varieties, integrate new crops, or plant several varieties, especially during dry periods (USAID, 2014).

A promising adaptation strategy for sesame is the adoption of new and improved pure sesame varieties. These varieties have superior oil content, color, and size compared to local seed, matching processors' and exporters' preferences. Improved varieties can simplify crop management activities due to homogenous fields (Gildemacher et al., 2015). Another advantage is yield 45% larger than local seed. One such new variety is called S43.

Other promising strategies target different points of the value chain. Sesame farmers can use seed drills for sowing to ensure efficient use of seeds and other inputs. The GIC in Burkina Faso encourages the uptake of solar-powered, mobile oil presses that increase the efficiency of oil extraction and to allow for off-grid processing (Green Innovation Centre Burkina Faso, 2018). The oil press cakes that are a byproduct of this process can be used as animal feed. Multi-cropping or targeted crop rotation with maize, sorghum, or legumes are also recommended soil management and diversification practices.

Opportunities exist to enhance sesame farmers' adaptation (Table 1). These include innovations like conservative soil tillage and the use of organic or biodegradable mulch material, the spreading of manure, and composting activities in zai pits should be strengthened (Savadogo et al., 2011). Constant training and retraining is important to ensure that farmers and other value chain actors remain up-to-date on new innovations and technologies.

Table 1. Specific practices within each practice group relevant to the focus value chains

STRATEGIES	SESAME VALUE CHAIN	RICE VALUE CHAIN
Water management	• Construction of barriers	• Implementation of alternating irrigation • Run-off water collection
Variety improvement	• Adoption of improved varieties, specifically S43*	• Adoption of improved varieties, specifically *orylux**
Organic inputs/ Fertilizer management	• Organic manure, fertilizer, and compost	• Organic manure • Use of neem oil in combination with fertilizers
Conservation agriculture	• Reduced tillage • Targeted crop rotation with maize, sorghum, or legumes • Mulching with organic and biodegradable materials	• Targeted crop rotation with maize, sorghum, or legumes • Mulching with organic and biodegradable material. • Intercropping with cowpeas and sesame • Integration of perennial crops
Improved rice management		• System of Rice Intensification
Land management	• The use of live hedges, grass strips, stone barriers, or terraces	
Climate services	• Early warning systems • Digital systems	• Early warning systems • Digital systems
Best agricultural practices	• Mechanization, processing, and transformation training • Using biproducts for animal feed	• Mechanization, processing, and transformation training
Post-harvest processing	• Solar-powered, mobile sesame press technology • Mechanization of post-harvest activities like winnowing and packaging	• Solar-powered rice mills • Solar bubble dryers • GEM parboiling technology
Energy switching	• Use of renewable energies and fuel saving technologies	• Solar-powered ovens • Use of rice hulls for energy production
Marketing	• SimAgri Market and Price Information System	• SimAgri Market and Price Information System • Contract farming
Finance	• Agricultural Entrepreneurial School • Farmer Business School	• Agricultural Entrepreneurial School • Farmer Business School

*Denotes that this is the highest-ranking adaptation strategy for its respective value chain.

6.1.2. Rice

Rice farmers can take advantage of many rice seeds, each adapted to irrigated, lowland, or rain-fed rice production systems. They can also implement the System of Rice Intensification (SRI), an innovation system aimed at increasing yields by using optimum inputs. The adoption of dual-purpose crops like sesame and cowpeas in addition to rice allows farmers to simultaneously increase monetary revenue while assuring food security. Ex-post-risk management coping mechanisms include, among others, the liquidation of assets, most commonly livestock.

Strategies exist to increase the resilience of the rice value chain to climate effects at both the on-farm production and post-harvest processing stages. Dry rice production with certified seed, implementing alternating irrigation, and the use of neem oil in combination with fertilizer are among potential adaptation strategies for the rice value chain. Establishing central cooperatives with solar-powered rice mills could save on processing labour, especially for the women who dominate this post-harvest activity. Capacity-building initiatives to support rice value chain are essential, as well as the use of digital and early warning systems to enhance the value of rice production in Burkina Faso (Green Innovation Centre Burkina Faso, 2018).

Rice production contributes significantly to high methane emissions, which must be considered in selecting adaptation strategies. SRI, the use of GAP, and sustainable energy use present possible mitigation options. Specific actions include using solar bubble dryers; using rice byproducts like husks, straw, and bran for energy production; and using either Grain quality enhancer, Energy-efficient and durable Material (GEM)[13] parboiling technology or solar-powered stoves for parboiling.

6.2. Overall ranking of the adaptation strategies

Relevant stakeholders were consulted to rank the adaptation strategies under consideration for both value chains. Participants were involved via an online survey. The survey was used to identify current and novel adaptation practices that reduce agricultural risk and help value chain actors cope with climate change. The assessments build on information collected from literature review and the current strategies implemented by the GICs in Burkina Faso. Potential adaptation strategies were presented to stakeholders, who ranked them on a scale of 1-8, with 1 implying a highly-ranked strategy and 8 a low one. The final ranking resulted in two top strategies for each hazard in each value chain. Overall, those most highly ranked focus on production intensification at the farm level.

Improved varieties ranked highly for both rice and sesame value chains. For sesame, the adoption of the S43 variety and the use of organic fertilizer were highly ranked for drought. Similarly, the adoption of the S43 variety and run-off water collection are highly ranked for floods. For rice, the highest ranked adaptation strategy for both drought and floods was the adoption of improved varieties (especially the *orylux* variety). The use of alternate irrigation and SRI were also highly ranked for drought (Table 2).

13 GEM combines the use of a uniform steam parboiler and an improved parboiling stove. This technology produces quality rice, is energy efficient and safer compared to traditional methods.

Table 2. Adapting to climate change: strategies across major value chain commodities

SESAME	INPUT	ON-FARM	POST-HARVEST	MARKETING
Floods	• Increased labor costs • Use of farmers' own seed • Demand for improved varieties	• Poor germination and capsule development • Mixing of varieties • Reduced sesame yields	• Discoloration of capsules • Pests and disease risks • Reduced quality of capsules (e.g., oil content)	• High consumer market prices
Magnitude of impact	MODERATE	MAJOR	MAJOR	MODERATE
Promising adaptation strategies	• Storm water collection • Mixed cropping or crop rotation with corn, sorghum, or legumes • Training in mechanization and transformation • The use of live hedges, grass strips, stone barriers, or terraces		• Early warning systems • Conservative methods of tillage • New S43 variety • SimAgri Market and Price Information System • Mobile seed cleaning and sorting operations	
Drought	• Increased costs of inputs • Necessity of improved seed varieties	• Water stress • Reduced quality and quantity of yield • Soil toxicity	• Reduced capsule yields • Poor quality • High processing costs	• High consumer prices • Reduced farmer income
Magnitude of impact	MINOR	MAJOR	MAJOR	MODERATE
Promising adaptation strategies	• Mixed cultivation or crop rotation with corn, sorghum, or legumes • Agricultural Entrepreneurship School • Organic fertilizers • Mechanization and transformation training • Utilizing byproducts such as oil press cakes for animal feed • Digital systems (such as the CIAT Soil Organic Carbon App)		• Mechanization of post-harvest activities like winnowing and packaging • Conservative methods of tillage • New S34 variety • SimAgri Market and Price Information System • Mobile cleaning and sorting operations • Use of renewable energies and fuel saving technologies • Use of seed drills	
Strategies to mitigate both hazards				
Farmers' coping strategies	• Re-sowing of seeds • Adopting new varieties and integrating new crops • Planting/sowing several varieties • Water conservation		• Soil management via use of organic manure, stone lines, NAR, and mulching • Water-control options like zai pits, half-moons, grass strips, and windscreens	
Potential strategies to increase farmers' adaptive capacity	• Targeted crop rotation • Conservative soil tillage • Use of organic or biodegradable mulch material • Mixed cultivation or crop rotation with maize, sorghum, or legumes • Integration of perennial crops into cultivation systems • Utilizing byproducts such as oil press cake for animal feed		• Use of organic manure and compost • Digital systems (such as the CIAT Soil Organic Carbon App) • Early warning systems • A single row, animal-drawn seed drill • Water management and control with hedges, grass strips, stone ramparts, terracing • Use of renewable energies and fuel-saving technologies	
GIC interventions	• New variety (S43) • Use of seed drills • The development of solar-powered, mobile oil presses • Organic fertilizer • Water harvesting		• Farmer Business School • Mechanization of production and processing • Demonstration farms • Mobile seed cleaning • Market and price information system SimAgri	

RICE	INPUT	ON-FARM	POST-HARVEST	MARKETING
Drought	• Demand for drought resistant varieties • Increased input costs	• Moisture stress • Poor growth and development. • Increased cost of production	• Small rice grains • Low quantities for processing • Increased processing costs	• Poor supply leads to high market prices • Reduced farmer incomes • Competition with cheaper imported rice
Magnitude of impact	MAJOR	SEVERE	MODERATE	MODERATE
Promising adaptation strategies	• Access to suitable and improved seeds • Storm water collection • Contract farming • Creating central cooperatives with mini rice mills powered by solar energy • Agricultural entrepreneurship school or Farmer Business School • Mechanization, processing, and transformation training • Solar-powered ovens • Alternate irrigation		• Early warning systems • Multiply the rice production plains with total control of irrigation water • Production of dry rice with certified seeds • Soil conservation • SimAgri Market and Price Information System • SRI • Mobile seed cleaning and sorting • Use of organic manure • Use of rice hulls for energy production	
Floods	• Increased input costs	• Impacts at flowering and fertilization stages • Increased incidence of pests and diseases	• Post-harvest losses due to poor quality rice grains	• Fluctuating market prices • Production costs exceed returns
Magnitude of impact	MODERATE	MAJOR	MAJOR	MAJOR
Promising adaptation strategies	• Access to suitable, improved seeds • Storm water collection and other water harvesting • The creation of central cooperatives with mini rice mills powered by solar energy • Agricultural entrepreneurship school and Farmer Business School • Mechanization, processing, and transformation training		• Alternate irrigation • Digital systems (such as the CIAT Soil Organic Carbon App) • Early warning systems • Production of dry rice with certified seeds • SRI • Use of Neem oil in combination with fertilizers	
Strategies to mitigate both hazards				
Farmers' coping strategies	• Adoption of new, dual-purpose crops • Use of improved rice varieties • Asset liquidation.			
Potential strategies to increase farmers' adaptive capacity	• Mixed cultivation or targeted crop rotation with maize, sorghum, or legumes • Conservative soil tillag. • Use of organic or biodegradable mulch material • Integration of perennial crops into cultivation systems		• Digital systems (such as the CIAT Soil Organic Carbon App) • Early warning systems • Single row, animal-drawn seed drills • Water control features like hedges, grass strips, stone ramparts, and terracing • Use of renewable energies and fuel-saving technologies	
GIC interventions	• Use of seed drills • Use of organic fertilizer • Water harvesting • Farmer Business School		• Training in mechanization, processing, and transformation • Demonstration farms • Mobile seed cleaning • Market and price information system SimAgri	

6.3. Cost benefit analysis of the prioritized adaptation strategies

KEY MESSAGES

» A Cost benefit analysis was computed for one of the highest ranked adaptation strategies.

» The use of improved rice variety (*Orylux*) was found to produce higher yields per acre compared to the local variety.

» Although it is capital intensive, it was found to be profitable and with a lower risk of making losses.

Cost and benefit analysis (CBA) is critical when making investment decisions, including those associated with CSA practices. This is because CBA allows for the comparison of costs and returns associated with a given CSA practice with those that are already existing, referred to as the business-as-usual (BAU) scenario. The comparison is important because most farmers in the developing world already have conventional practices that help them cope with climate change variabilities. Some of them have been effective while others have had no impact on climate change (Ng'ang'a et al., 2017). Three indicators from the CBA are used to show the profitability associated with an improved or innovated practice. Net Present Value (NPV) measures the incremental flow of net benefits from the innovation over its lifecycle; Internal Rate of Return (IRR) is the discount rate that equates NPV to 0, with a higher IRR indicating a high profitability potential; payback period, or the number of years it takes to recoup the initial investment. A shorter payback means that the innovation is more appealing for investors.

The CBA was computed for the highest-ranked innovations under rice, a recently-developed, improved variety called *Orylux*. *Orylux* is considered suitable across a range of environments and is tolerant to water stress. It is also adapted to the existing climate of Burkina Faso (including its drought risks) and has characteristics preferred by a large number of consumers. Finally, its yield is higher per unit hectare is higher than the local variety. However, the implementation and maintenance of a new improved variety of rice seed require more 21% more capital than in the BAU case (Table 3). Notably, there was no change in operation costs between the BAU scenario and the use of an improved variety of seed; therefore, the main benefits of improved seeds emanate from increased yield per hectare (Figure 11).

The NPV, IRR, payback period, and risk associated with using the *Orylux* variety of rice were all positive indicators (Table 4). The NVP was US$ 2,248 per hectare. The IRR was more than 100%, higher than the prevailing discount rate of 6.5%. Investing in *Orylux* rice variety had a payback period of 1 year, meaning that the use of this improved variety is appealing to farmers because of the short payback period. A longer payback period can act as a barrier to the adoption and scaling up of innovations. Risk was calculated using Monte Carlo simulation (n = 10,000), which indicated a very low level of risk, less than 3%.

Table 3. Summary information on costs for BAU and improved seed variety in the rice value chain in Burkina Faso

VALUE CHAIN (INNOVATION)	INSTALLATION COSTS (US$/HA)			MAINTENANCE COSTS (US$/HA)			OPERATION COSTS (US$/HA)		
	BAU	IMPROVED VARIETY	*% CHANGE*	BAU	IMPROVED VARIETY	*% CHANGE*	BAU	IMPROVED VARIETY	*% CHANGE*
Cost in US$/ha	447.1	545	*+21*	1,219	1,485	*+21*	313	312	*-0.003*

Figure 11. Yield for BAU versus use of improved rice seed in Burkina Faso

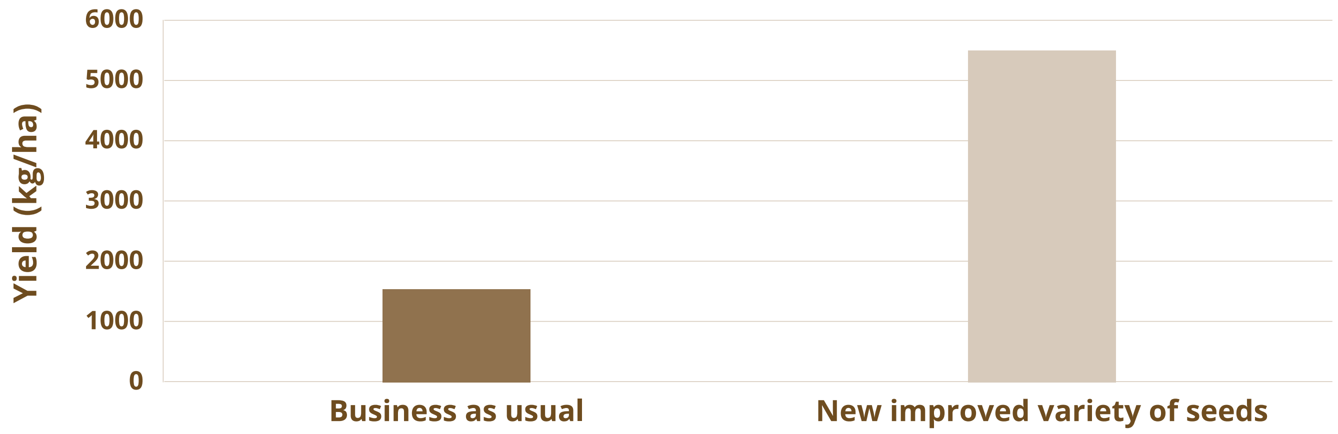


Table 4. CBA analysis for improved seed variety in Burkina Faso

VALUE CHAIN	INNOVATION	PROFITABILITY INDICATORS			
		NPV IN US$	IRR IN (%)	PAYBACK PERIOD (YEARS)	RISKINESS OF INVESTMENT
Rice	New, improved variety or rice (*Orylux* variety)	2,448	More than 100% (>r)	1	This innovation has about a 3% probability of unprofitable returns

NB: >r implies that the practice is privately profitable per hectare basis

7. SYNTHESIS AND RECOMMENDATIONS

Future climate projections for Burkina Faso show a likely acceleration of flood and drought risks, high temperatures, and a decline in precipitation. These changes and variations will continue to negatively impact agricultural production. Droughts and floods will adversely impact the rice and sesame value chains through an increase in production and transaction costs, ultimately leading to low farm incomes. The impacts will, however, vary regionally, with the Boucle-du-Mouhoun region being the most affected.

Farmers in the rice and sesame value chains use various adaptation strategies to cope with the effects of climate change at the farm level. Nonetheless, these strategies still have low adoption rates. Major impediments to adoption include lack of financial resources, poor access to improved technologies, and lack of the knowledge and skills necessary to implement these technologies. Building farmers' capacity, through enhanced training using platforms like Farmer Business Schools, for example, helps in promoting the adoption of innovations. Propositions such as integrating indigenous and scientific knowledge are important not only in enhancing farmers' understanding of climate change, but also for enabling the adoption of better adaptation options (Kima, 2015). Such an integration can be achieved through the provision of frequent climate forecasts and engaging farmers in their validation. Farmers should also be incentivized to use climate and forecasting information to plan their cropping calendars.

The use of the improved *Orylux* rice variety is thought to have good potential for coping with drought. Despite limitations such as potential inaccuracies in identifying and quantifying costs and benefits for a given innovation, CBA analysis is critical for planning future investments and for informing upscaling. CBA shows that using the *Orylux* variety is profitable, with a high return and with a short payback period. These factors indicate why it was highly ranked by stakeholders. It is considered, in this CBA, a 'no-regret option,' implying that it will yield economic benefits now and in the future. It is, therefore, a key innovation for strengthening future household resilience. Despite high implementation and maintenance costs, when NPV is considered, the use of an improved seed variety for rice has a low likelihood of being unprofitable, cementing the economic case for its implementation. This is key, given that the GIC is interested in identifying innovations that can produce desirable outcomes for a majority of smallholder farmers in Burkina Faso.

Burkina Faso has the institutional capacity capable of supporting the implementation of climate-smart technologies for sesame and rice production and agricultural production at large. Presently, the country does not have an exhaustive policy or strategy on climate change, although climate change has been incorporated in ongoing adaptation plans. This means that the government of Burkina Faso needs to give attention to creating an enabling policy environment in order to deal with the worsening effects of climate change in the future. Ensuring water availability, through investment in irrigation facilities and planification of dams, is a priority.

Going forward, a variety of opportunities for collaboration, funding, and synergies exist for these practices (Table 5). Several organizations are well positioned to offer general support across all potential activities, including:

- Ministry of Agriculture, Water, and Fishery Resources
- Système National de Vulgarisation et d'Appui Conseil Agricole (SNVACA)
- The Environmental Institute for Agricultural Research (INERA)
- The West and Central African Council for Agricultural Research and Development (CORAF)
- Institute for Research in Applied Science and Technology (IRSAT)
- West Africa Agricultural Productivity Programme (WAAPP)
- Centre International de Recherche-Développement sur l'Elevage en Zone Subhumide (CIRDES)
- Farmers' Cooperatives, such as the Association National d'Action Rurale (ANAR), and the Federation Nationale des Groupements Naam (FNGN)

Further, several barriers challenge the general implementation of climate-aware programming in Burkina Faso. These include:

- High levels of poverty
- Low levels of literacy
- Low Human Development Index levels
- Gender inequalities in farming, particularly in women's lack of access to financial products like credit and risk insurance
- Lack of institutional support, for example, in provision of improved seeds, which is constrained by farmers' inadequate financial access but also by the lack of an efficient seed disbursal system
- Poor market infrastructures contribute to price volatility increases food insecurity and the financial burdens of smallholder farmers
- Lack of a specific, overarching policy on climate change at the national level

Table 5. Practice-group specific potential strategies and considerations for advancing CSA at scale

PRACTICE GROUP	PARTNERSHIPS	BARRIERS	EXISTING AND POTENTIAL FUNDING	SYNERGIES
Water management	• Ministry of Agriculture, Water, and Fishery Resources • Systeme National de Vulgarisation et d'Appui Conseil Agricole (SNVACA) • Local farmers' groups • Local governments	**Farm level barriers:** • Financial constraints • Dependence on rainfall **Institutional barriers:** • Lack of access to education and information • Insufficient availability of technology	• Public and private interests with good blended finance potential	• Supports climate-resiliency and yields, thus improving market stability
Variety improvement	• Ministry of Agriculture • Environmental Institute for Agricultural Research (INERA) • West and Central African Council for Agricultural Research and Development (CORAF) • The Institute for Research in Applied Science and Technology (IRSAT) • Albert Schweitzer Ecological Center (CEAS) • University of Ouagadougou (UO) • Africa Rice Research Center • Food and Agriculture Organization (FAO) • GIZ • The International Rice Research Institute (IRRI)	**Farm level barriers:** • Financial constraints • Insufficient availability of seed **Institutional barriers:** • Disorganized distribution system • Lack of access to education and information	• International research funding offers robust support • Diversification toward local and culturally important crops needed	• Supports climate-resiliency and yields, thus improving market stability

PRACTICE GROUP	PARTNERSHIPS	BARRIERS	EXISTING AND POTENTIAL FUNDING	SYNERGIES
Organic inputs/fertilizer management	• Albert Schweitzer Ecological Center (CEAS) • Ministry of Agriculture University of Ouagadougou (UO) • Africa Rice Research Center • Food and Agriculture Organization (FAO) • GIZ • The International Rice Research Institute (IRRI)	**Farm level barriers:** • Capital constraints • Knowledge gaps • Financial constraints **Institutional barriers:** • Inadequate access to inputs • Low access to finance • Weak land tenure security • Inconsistent extension services • Poor financial service availability	• Good potential for green blended finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term land productivity	• Supports niche markets, including international markets, attracts finance, and supports conservation agriculture and land restoration • Supports climate resiliency and yields, maximizes cost efficiency of fertilizer inputs, and minimizes environmental impacts • Supports robust markets
Conservation agriculture	• Albert Schweitzer Ecological Center (CEAS) • Ministry of Agriculture • Environmental Institute for Agricultural Research (INERA) • West and Central African Council for Agricultural Research and Development (CORAF) • The Institute for Research in Applied Science and Technology (IRSAT)	**Farm level barriers:**** • Capital constraints • Knowledge gaps **Institutional barriers:**** • Limited land access and land tenure	• Good potential for blended green finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term productivity	• Improved soil health supports yields and water retention, thus increasing both market stability and climate resiliency
Improved rice management	• Africa Rice Research Center • Food and Agriculture Organization (FAO) • GIZ • The International Rice Research Institute (IRRI)	**Farm level barriers:**** • Capital constraints • Knowledge gaps **Institutional barriers:**** • Inconsistent extension support	• Good potential for blended green finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term productivity	• Supports climate-resiliency and yields, thus improving market stability

PRACTICE GROUP	PARTNERSHIPS	BARRIERS	EXISTING AND POTENTIAL FUNDING	SYNERGIES
Land management	• Ministry of Agriculture • Environmental Institute for Agricultural Research (INERA)	**Institutional barriers:**** • Cross-institutional coordination • Enforcement of regulation • Balancing livelihood and environmental priorities	• Good potential for blended green finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term productivity	• Improved soil health supports yields and water retention, thus increasing both market stability and climate resiliency
Climate services	• Association National d'Action Rurale (ANAR) • Federation Nationale des Groupements Naam (FNGN) • Agency for the Promotion of Small- and Medium-Sized Agricultural Enterprises and Handicrafts (APME) • Institut de Développement Rural (IDR) • Sasakawa Africa Fund for Extension Education (SAFE) • Long Live the Farmer Association • Centre International de Recherche-Développement sur l'Elevage en Zone Subhumide (CIRDES)	**Farm level barriers:** • Low levels of access to electricity, radio, and television **Institutional barriers:** • Insufficient access to technologies • Insufficient access to knowledge and education	• Public and private interests with good blended finance potential	• Supports efficiency and planning in input provision, production, postharvest transport and processing, and marketing
Best agricultural practices	• Ministry of Agriculture • Centre International de Recherche-Développement sur l'Elevage en Zone Subhumide (CIRDES) • Handicrafts (APME) • Institut de Développement Rural (IDR) • Sasakawa Africa Fund for Extension Education (SAFE)	**Farm level barriers:**** • Capital constraints • Knowledge gaps **Institutional barriers:**** • Inconsistent extension support	• Good potential for blended green finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term productivity	• Supports climate-resiliency and yields, thus improving market stability

PRACTICE GROUP	PARTNERSHIPS	BARRIERS	EXISTING AND POTENTIAL FUNDING	SYNERGIES
Post-harvest processing	• Ministry of Agriculture • Economic Community of West African States (ECOWAS) • Food and Agriculture Organization (FAO) • Agency for the Promotion of Small- and Medium-Sized Agricultural Enterprises and Handicrafts (APME) • Institut de Développement Rural (IDR)	**Farm level barriers:** • - **Institutional barriers:** • Insufficient access to finance • Insufficient access to improved technologies • Limited storage capacity	• High potential for private sector investing	• Best processing practices reduce losses in storage and in transport to market, thus stabilizing supplies
Energy switching	• Association National d'Action Rurale (ANAR) • Institut de Développement Rural (IDR)	**Farm level barriers:**** • Competing priorities for energy resources **Institutional barriers:**** • Limited infrastructure • High upfront cost, especially last mile	• Public and private interests with good blended finance potential	• Relieving energy pressure biomass resources supports conversation agriculture, land restoration, and the benefits thereof
Marketing	• Economic Community of West African States (ECOWAS) • Food and Agriculture Organization (FAO)	**Farm level barriers:** • - **Institutional barriers:** • Poor physical infrastructure (e.g., roads) • Restrictive trade policies	• High potential for private sector investing	• Reliable storage and processing systems support market stability and consumer confidence • Organic inputs support niche marketing
Finance	• Agency for the Promotion of Small- and Medium-Sized Agricultural Enterprises and Handicrafts (APME) • Institut de Développement Rural (IDR) • Long Live the Farmer Association	**Farm level barriers:**** • Knowledge gaps • Financial constraints **Institutional barriers:**** • Poor access to credit • Poor availability of farmer-targeted financial services, including loan, credit, savings, and warehouse receipts**	• Blended finance, using public funds as a de-risking instrument, delivered through cooperatives to support farmer-initiated investments in long-term land productivity	• Enable on-farm investments in soil fertility, optimized management techniques, and climate resiliency

** based on literature

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